STRAITS METEOROLOGY.

IN the Annual Summary for 1882, the Officer who is responsible for our Meteorological Statistics stated, truly enough, that "an exhaustive report on the Meteorology "of these Settlements cannot yet be attempted, as the "subject is still in its infancy here." But it does not seem too early to endeavour to obtain some results from the series of Rainfall Returns (1869-83) which the Colonial Government commenced to keep in Singapore soon after the Transfer, and which are now taken with increasing care at nearly twenty stations, situated at intervals along the whole West Coast of the Peninsula. A wider range of observations is also now available in the comparative Tables compiled by the Director of the Batavia Observatory from 166 stations in the Eastern Archipelago, the fourth volume of which (for 1882) has just been received.

The year 1882-3 has been one of peculiar interest to meteorologists. It was both a "sun-spot" year and a "cholera" year, the respective 11-year and 17-year periods happening to correspond. Nor have the theorists been disappointed.

It becomes of interest, therefore, to examine our local Returns with special attention, incomplete though they undoubtedly are for any large generalisations.

In the first place, what are these theories respecting the periodicity of solar and magnetic phenomena and all that is supposed to be connected with them? The last published volume of the new edition of the "Encyclopædia Britannica" (vol. XVI of 1883) explains them, on the highest authority, as follows :—

"105. *Rainfall—Heights of Rivers and Lakes.*—In 1872 MELDRUM of the Mauritius Observatory brought forward evidence showing that the rainfalls at Mauritius, Adelaide, and Brisbane were, on the whole, greater in years of maximum than in years of minimum sun-spots. Shortly afterwards it was shown by LOCKYER (*Nature*, December 12, 1872) that the same law was observable in the rainfalls at the Cape of Good Hope and Madras.

"MELDRUM has since found that the law holds for a great number of stations, including eighteen out of twenty-two European observatories, with an average of thirty years' observations for each. The results are exhibited in the following table:—

[Here follows a list of 22 cities with observations for an average of 30 years, shewing in 18 cities *excess* and in 4 cities *defect* of rain in the periodical "sun-spot" years.]

"It would, however, appear from the observations of Governor RAWSON that the rainfall in Barbados forms an exception to this rule, being greatest about the times of minimum sun-spots.

"106. GUSTAV WEX in 1873[1] showed that the recorded depth of water in the rivers Elbe, Rhine, Oder, Danube and Vistula for the six sun-spot periods from 1800 to 1867 was greater at times of maximum than at times of minimum sun-spot frequency. These conclusions have since been confirmed by Professor FRITZ.[2]

"Quite recently STEWART (*Proc. Lit. and Phil. Soc. of Manchester*, 1882) has treated the evidence given by FRITZ as regards the Elbe and Seine in the following manner. He divides each sun period, without regard to its exact length, into twelve portions, and puts together the recorded river heights corresponding in time to similar portions of consecutive sun periods. He finds by this means residual differences from the average representing the same law, whether we take the whole or either half of all the recorded observations, and whether we take the Elbe or the Seine. The

1 *Engenieur Zeitschrift*, 1873.

2 *Ueber die Beziehungen der Sonnenflecken Periode zu den Magnetischen und Meteorologischen Erscheinungen der Erde*, Haarlem, 1878.

law, is that there is a maximum of river height about the time of maximum sun-spots and another subsidiary minimum about the time of minimum sun-spots. There is some reason too to think that the Nile and Thames agree with those rivers in exhibiting a maximum about the time of maximum sun-spots and a subsidiary maximum about the time of minimum sun-spots, only their subsidiary maximum is greater than it is for the Elbe and Seine.

"107. In 1874 G. M. Dawson came to the conclusion that the levels of the great American lakes were highest about times of maximum sun-spots. In this investigation the value of the evidence derived from rivers and lakes is no doubt greater than that derived from any single rainfall station, inasmuch as in the former case the rainfall of a large district is integrated and irregularities due to local influence thus greatly avoided.

"108. Dr. Hunter, director-general of statistics in India, has recently shown (*Nineteenth Century*, November 1877) that the recorded famines have been most frequent at Madras about the years of minimum sun-spots—years likewise associated with a diminished rainfall.

"109. *Winds and Storms.*—Meldrum of the Mauritius Observatory found in 1872, as the result of about thirty years' observations, that there are more cyclones in the Indian Ocean during years of maximum than during years of minimum sun-spots.[1] The connexion between the two is exhibited in the following table":—

[Here follows a comparison of the Cyclones and Sun-spots during the years 1847-73. The maximum number of Cyclones in any one year is 15, the minimum 4, and the steady *ups* and *downs* of the periodic fluctuations are very remarkable. The following are the years of maximum and minimum Cyclones:—

1847,	5	Cyclones
1849,	10	„
1854,	4	„
1859,	15	„
1864,	5	„
1869-71,	11	„ per annum.

1 *Br. Assoc. Reports, 1872.*

The course of the periodic wave in this table and in the one below exhibiting the Straits rainfall, closely correspond.]

"In 1873 M. Poëy found a similar connexion between the hurricanes of the West Indies and the years of maximum sun-spots. He enumerated three hundred and fifty-seven hurricanes between 1750 and 1873, and stated that out of twelve *maxima*, ten agreed.

"110. In 1877 Mr. Henry Jeula, of Lloyd's, and Dr. Hunter found that the casualties of the registered vessels of the United Kingdom were 17½ per cent. greater during the two years about maximum than during the two years about minimum in the solar cycle.

"111. *Temperature.*—Baxendell, in a memoir already quoted, was the first to conclude that the distribution of temperature under different winds, like that of barometric pressure, is sensibly influenced by the changes which take place in solar activity. In 1870 Piazzi Smyth published the results of an important series of observations made from 1837 to 1869 with thermometers sunk in the rock at the Royal Observatory, Edinburgh. He concluded from these that a heat wave occurs about every eleven years, its maximum being not far from the minimum of the sun-spot cycle. Sir G. B. Airy has obtained similar results from the Greenwich observations. In 1781 E. J. Stone examined the temperature observations recorded during thirty years at the Cape of Good Hope, and came to the conclusion that the same cause which leads to an excess of mean annual temperature at the Cape leads equally to a dissipation of sun-spots. Dr. W. Köppen in 1873 discussed at great length the connexion between sun-spots and terrestrial temperature and found that in the tropics the maximum temperature occurs fully a year before the minimum of sun-spots, while in the zones beyond the tropics it occurs two years after the minimum. The regularity and magnitude of the temperature wave are most strongly marked in the tropics."

It has been thought best to give the whole of this well-digested summary, as it presents, under the authoritative initials of "B. S.,"

the latest information upon the whole question, from an impartial standpoint. The mere reference here made to Dr. HUNTER and others is, however, so brief as to suggest but a fractional part of what has already been done to establish as a fact the recurrence of " the sun-spot and famine period," especially in India.

Since the article in the Encyclopædia, from which I have quoted, was written, the outbreak of Cholera in Egypt last autumn has drawn special attention to the periodicity of that mysterious disease. An account of its recurrence in this century was published in the *Times* last July, without any reference to any question of periodicity, but it was impossible to overlook the similarity of the intervals marked by the dates there given :—

* 1832, 1849, 1866, 1883.

The connection between Meteorology and periodical epidemics forces itself into special notice in this Colony, with regard not only to Cholera, but to another mysterious and fatal disease—" Beri-Beri "—which is a far greater local scourge.

The following extracts from recent official reports regarding outbreaks of each disease will sufficiently show the claim which this matter has on our attention :—

" *Amount of Rain during Cholera Epidemic.*

" 109. From the Return attached *(G)* it will be seen that the total rainfall for the year was 66.19 inches, about 30 inches below the average, I believe. During the months when the Cholera prevailed the rainfall was as under :—

1882.			*Inches.*
March,	...	...	2.57
April,	...	...	4.40
May,	...	...	2.36
June,	...	...	3.73
July,	...	...	2.92

* This was the first appearance of Cholera in Europe, but it will be remembered that it was in 1798 [1832 *less* (17 × 2)] that occurred the historical outbreak in Egypt by which BONAPARTE'S movements were so hampered.

so that in those five months the rainfall was rather less than a quarter of that which fell in the year."* [Malacca Administration Report, 1882.]

The facts as regards "Beri-Beri" relate to the recent outbreaks in the Singapore Prison, and are shown in an official report as follows:—

"Amount of Rain and number of Beri-Beri Cases:—

	Numbers.	Deaths from Beri-Beri.	Rainfall.
1877, ...	814	22	61 inches.
1878, ...	845	65	99 „
1879, ...	777	106	118 „
1880, ...	626	87	102 „
1881, ...	642	35	92 „
1882, ...	806	50	79 „
1883, ...	837	27	66 „ "

As regards another local disease, "Country Fever," the following authoritative statement on this subject is to be found in the new Encyclopœdia's article "*Malaria*":—

"The epidemic prevalence of intermittent and remittent fever in certain years probably finds its explanation in the meteorology of those years, but no uniform law has been discovered."

A subject of more general interest, and one which has already excited some discussion in the Straits, has reference to the effects on rainfall of disafforesting a country. Some say that the loss of our timber has diminished the supply of rain; others deny it, and

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* The Cholera which visited this Colony at the very commencement of the long drought 1882-3 seems to have followed the course of defective rainfall in the various Settlements with remarkable precision—and as the disease appeared rather before than after the rainfall phenomena of the period had declared themselves, the influence must, it seems, have been less hygrometric than magnetic in its origin. The following are the facts:—

In Malacca,	65 inches in 1882,	...	The epidemic was worst.
In Singapore,	88 „ „	}	The epidemic was less felt.
In Prov. Wellesley,	92 „ „	}	
In Penang,	126 „ „	...	There was not a single case.

The *average* rainfall is much the same in all the Settlements.

point to the Rainfall Returns as conclusive. Of this difference of opinion, an example was afforded in the apparently contradictory views published in the Forest Report, 1883, paragraph 25 and Appendix *E*.

In 1880, Mr. WHEATLEY, in his most useful paper on our Rainfall in Journal No. VII, was careful to express no definite opinion; though the necessities of his argument about "the one great influence at work—the monsoons" required him to attach little weight to any local cause.

The enquiry into the degree and mode of this "monsoon" influence has, since he wrote, been much facilitated by the extension of the Dutch observations in Netherlands India, to which I have referred above. The Director, Dr. VAN DER STOK has kindly sent me his Records of Rainfall, in which he is now able to give the mean for four years in 166 stations throughout this great region. The following summary of the 20 principal places, named in geographical order, to the North and South of the Equator respectively, has been compiled from these Dutch Returns; and they show how closely the degree of excess or defect of rain in 1882 followed the degree of North or South in the observing station. The fact of excess or defect is, it will be seen, entirely governed (except in the case of three headlands) by the question whether a place lies North or South of the Equator, which is in this matter presumably equivalent to "monsoon" influence.

TABLE OF NETHERLANDS INDIA STATIONS.

Comparing the Rainfall in 1882 *with the Mean Annual Amount.*
(*in millimetres.*)

[The places in brackets are headlands exceptionally situated, which differ from neighbouring places less exposed. It is noticeable also that while the rest of the Straits followed the law here observed and had deficient rain, Penang, which belongs rather to further India than Malaya, had a marked excess.

The places in italics lie South of the Equator.]

	Average of 4 years M. M.	Rainfall 1882. M. M.
(Acheen) ...	1,769	1,806
Deli ...	2,233	1,840
Rio ...	2,623	2,430
Jambi ...	2,484	2,154
Palembang ...	3,075	3,147
(Anjer) ...	2,101	2,034
Batavia ...	2,012	2,460
Sourabaya ...	1,854	2,856
(Banjoewangi) ...	1,485	1,446
Tjilatjap ...	5,054	5,490
Bencoolen ...	3,173	3,209
Padang ...	4,640	4,673
Singkel ...	4,455	4,057
Celebes — Menado 2° N. ...	2,647	2,880
Celebes — *Macassar* 5° S. ...	3,562	4,203
Moluccas — Ternate 2° N. ...	2,402	2,326
Moluccas — *Banda* 4° S. ...	3,118	3,488
Borneo — Pontianak (on the Equator)	3,090	3,096
Borneo — (*Banjermasin* 3° S).	2,519	2,609

Whether or not "monsoon" laws usually have such ruling influence, there can be little doubt that the effect of disafforestment on the annual rainfall, whatever it may be elsewhere, is at a minimum in the Straits. The difference of opinion on this point is, it may be surmised, partly due to some confusion between the mean annual rainfall and the periodical distribution of rain (as recorded in the numbers of days on which rain fell), and to a want of sufficient discrimination in the further matter of distribution, *viz.*, the loss or storage of the rain after falling, which is probably the most important point of all to agriculturists, though one with which meteorology is only indirectly concerned.

There can be no doubt that temperature, on the other hand, is closely affected, here as elsewhere, by the loss of forest and by the spread of buildings. The existence of Singapore now covers

two generations; the experience of the first generation was summed up by Mr. CRAWFURD in 1855 with the following statement (Descriptive Dictionary p. 396) :—

" *(a)* January is the wettest and coldest month of the year.

" *(b)* The average rainfall in " a series of years " is 92.69.

" *(c)* The mean temperature is 81.24 and the range from the " mean of the hottest month to that of the coldest is 2.76 only.

" *(d)* Comparing this with the temperature that was ascertained " in the infancy of the Settlement, it would appear that it has " increased (1855) by 2.48, a fact ascribable, no doubt, to the increase " of buildings, and to the country having been cleared of forests " for several miles inland from town, the site of the observations."

A similar summary could most usefully be prepared in 1885 for comparison and record.

The most interesting question of all for our meteorologists is that with which this paper commenced—the question whether we have here recurring periods of drought and rain, due to sun-spots or magnetic influence of some kind. If there is any such period due to solar influence, why, compared with that influence, even the " monsoon " shrinks into a " local " cause, and becomes of comparatively little importance. Mr. WHEATLEY did not like " to " hazard, even by guessing, a rule by which the rainfall of Singa- " pore can be calculated upon." But the Tables he published show that in fact the period of 10½ to 11 years, and the subsidiary period of about 5 years, are peculiarly well-marked in Singapore. Take his figures in Tables VII and VIII, for example: the total numbers of dry days for the 17 years 1864-80 are given for each month the annual totals being as follows :—

1864, 19	1870, 15	1876, 11
1865, **12**	1871, 7	1877, *11*
1866, 18	1872, *13*	1878, 9
1867, *23*	1873, 11	1879, **7**
1868, 13	1874, **9**	1880, 8
1869, **9**	1875, 10	

The size of the type is intended to make the periodic fluctuation clearer. But the resources of typography do not permit the full regularity of the recurrence to be shown without a diagram, and careful attention is invited to the whole series of figures published in Journal No. VII.

It will be seen, for example, that the driest years in their respective periods are 1866-7 and 1876-7, and the least dry 1869 and 1879-80.

A comparison of the exceptionally dry months, January-March 1867, (35 dry days) with August-September 1877, (27 dry days) and of the exceptionally wet months, October-December 1869 (8 dry days) with March-May 1880 (9 dry days) marks the period as one of $10\frac{1}{2}$ years still more precisely.

The same thing is shown by the Table II of Annual Rainfall there published; the table being brought up to date. the totals for each periodic year are as follows :—

wet years	inches	dry years	inches
1870 ...	123.24 ...	1872-3	91.01
1875 ...	108.48 ...	1877	61.19
1879-80 ...	111.34 ...	1882-3	73.33

The mean Annual Rainfall may be roughly taken at 100 inches.

[A diagram with a curved line, starting from the end of 1869 for the maximum rain, and from the middle of 1872 for the minimum rain, will be found to move up and down with an almost perfectly regular curve.]

It is certainly well to wait until we have a larger series of Annual Returns before generalising on such a matter too positively; and this branch of the subject is only touched upon now to invite the attention of all who may keep or study our Meteorological Records. But from the evidence already accumulated, the long drought of 1882-83, which ended last August, was, I maintain, clearly to be anticipated; for it closed the solar period dating from the limited rainfall (160 inches) in 1872-3, and the subsidiary dry period, showing the fall of 148 inches only, in 1876-7.

An excess of rain may, in the same way, be looked for in the years 1884-5, and still more in 1885-6 : but not so great an excess, these years merely closing the subsidiary period of excess from 1879-80 (228 inches). It was the year 1880 that closed the full periodic term dating from the phenomenal rainfall of the rainy term—August 1869 to December 1870—(173 inches).

By such calculations as these, predictions about the Rainfall may, I think, be hazarded even now, notwithstanding that we still have insufficient means of deciding the scientific laws that govern the subject.

A. M. SKINNER.